

Claims

I claim:

- 1 1. A method for decoding an $[N, k]_q$ sparse transform factor graph code using a soft-
2 input cost function, comprising:
3 a one-time initialization procedure; comprising:
4 constructing a sparse transform factor graph representation of the
5 code;
6 selecting an encoding method consistent with the representation;
7 selecting a message-passing decoder method consistent with the
8 representation;
9 initializing messages of the selected decoder method according to the
10 soft-input cost function; and
11 an iterative decoding procedure, comprising:
12 updating messages according to message-update rules of the selected
13 decoder;
14 outputting a code word when a termination condition is true, and
15 otherwise repeating the iteration of the decoding procedure.
- 1 2. The method of claim 1, in which the code is a Reed-Solomon code.
- 1 3. The method of claim 1, in which the code is an extended Reed-Solomon code.
- 1 4. The method of claim 1, in which the code is a punctured Reed-Solomon code.
- 1 5. The method of claim 1, in which the code is a extended ternary Golay code.

- 1 6. The method of claim 1, in which the code is a non-binary code.
- 1 7. The method of claim 1, in which the sparse transform factor graph includes
2 input-output factor nodes, each input-output factor node has k input variables
3 entering the node from the left, and k output variables exiting the node from the
4 right, and the input variables and the output variables are related by $2k$ constraints,
5 where k is a rank of the input-output factor node.
- 1 8. The method of claim 7, in which the rank k is two.
- 1 9. The method of claim 7, further comprising:
2 stacking and layering the input-output factor nodes.
- 1 10. The method of claim 1, wherein the sparse transform factor graph code is a fast
2 sparse transform factor graph code.
- 1 11. The method of claim 1, further comprising:
2 simplifying the sparse transform factor graph representation.
- 1 12. The method of claim 11, further comprising:
2 generating a plurality of the simplified sparse transform factor graph
3 representations; and
4 combining the plurality of the simplified sparse transform factor graph
5 representations into a redundant sparse transform factor graph representation.

- 1 13. The method of claim 1, in which the message passing decoding method
2 includes message-update rules and belief-update rules.
- 1 14. The method of claim 1, in which the messages are initialized to zero.
- 1 15. The method of claim 1, in which the iterative decoding procedure further
2 comprises:
 - 3 determining a trial code word from the messages, the selected decoder
4 method and the encoding method;
 - 5 determining a cost of the trial code word using the soft-input cost function;
 - 6 updating a tentative code word with the trial code word if the trial code word
7 has lower cost than the tentative code word; and
 - 8 terminating by outputting the tentative code word when the termination
9 condition is true, and otherwise repeating the iteration of the decoding
10 procedure.
- 1 16. The method of claim 15, in which an initial cost of the tentative code word is
2 infinity.
- 1 17. The method of claim 15, in which the termination condition is fixed number of
2 iterations.
- 1 18. The method of claim 1, further comprising:
2 combining the selected decoder with a with a different decoder.

1 19. The method of claim 1, further comprising:
2 combining the selected decoder with a hard-input bounded-distance decoder
3 that uses thresholding.

1 20. The method of claim 1, further comprising:
2 concatenating the selected decoder with a different soft-input decoder.

1 21. The method of claim 10, in which the fast sparse transform factor graph has M
2 q -ary input and output variables, and where N input, internal, and output transform
3 variables in the fast sparse transform factor graph are connected to soft-constraint
4 factor nodes, and $M-k$ of the input variables are connected to factor nodes that
5 constrain the input variables to equal zero.

1 22. The method of claim 21, in which the fast sparse transform factor graph
2 includes hard-constraint equality constraint factor nodes to copy the internal
3 transform variables that are connected to the soft-constraint factor nodes.